SEGA/Gremlin
Color X-Y Monitor
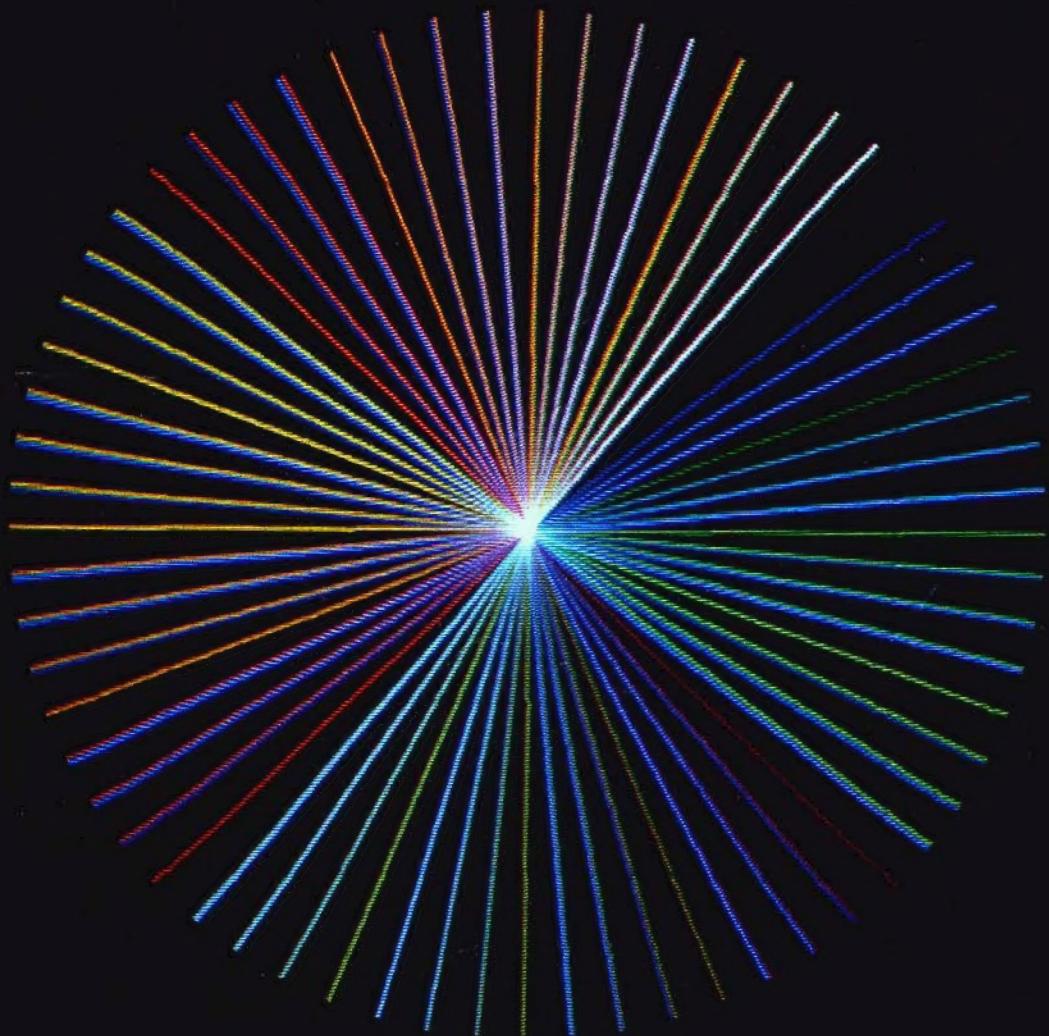
Color X-Y Monitor
Service Manual

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PREFACE

With the introduction of its new color X-Y game, SEGA/Gremlin is changing the look of video games in the 80's. The new color X-Y technology is at once the most innovative outlet for game concepts that before existed only in the minds of the designers. However, this new technology creates an immediate need for an understanding of how it works and how to keep it working. That is the reason for this manual. The manual describes the operation of the color X-Y monitor, as well as the two new G-80 boards (TIMING and CONTROL) that control the monitor. In addition, a maintenance section is provided, as is a complete color X-Y monitor parts catalog. Reference is made in this manual to the four other G-80 boards (SPEECH, CPU, EPROM, SOUND) but complete schematics, parts lists and descriptions for these boards can be found in the game manual. Also provided in the manual is a glossary of color X-Y terms.

The copy in the manual is printed in light and bold face type. This is done to direct the reader to all light face print for a basic understanding of the X-Y system; material printed in bold face takes the reader deeper into the subject matter by offering a more technical explanation. One more thing...Be sure to read the manual *before* attempting any repairs or adjustments to your games. Now, read on!

SEGA/Gremlin
Technical Publications Department

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INTRODUCING...
# THE COLOR
X-Y MONITOR!

**Raster-Scan
Verus
X-Y Monitor**

To introduce the workings of the color X-Y monitor, let's first pay tribute to the "other kind of monitor"—the raster-scan. You may remember, from your knowledge of raster-scan displays (like those in a TV), that the electron-beam inside the tube always moves in a predictable way. That is, it always starts at the top left of the screen and scans across it, forming a pattern of horizontal lines on the inside surface of the tube as it moves downward. When it gets to the bottom, the beam is forced back to its starting point and repeats the raster-scan movement. To create a simple display (for example, a large "+" symbol) on the raster-scan monitor, we figure out, first, *where* we want it to appear on the screen; let's say the center, in this case . Then we generate a video signal that represents the "+", plug the signal into the monitor and, presto, we get a "+" on a raster-scan display! What we have done is intensify the electron-beam so that *only* those points corresponding to the "+" light up on the raster. Here's how it would look close-up:

Raster-Scan
Display———▶

Nice Line
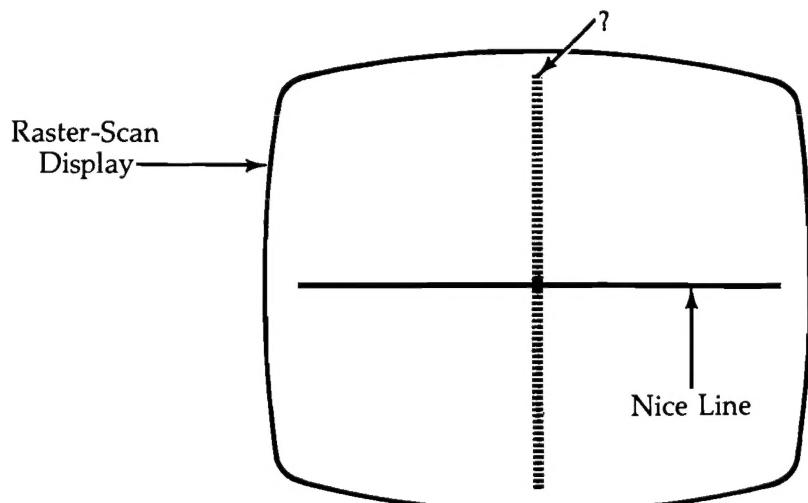
See anything unusual? Notice how the vertical line is not much of a line, but more a column of stacked "—'s". This occurs because the raster lines, which run horizontally inside the CRT, are spaced slightly as the beam traces them.

So, what we see, looking at our line from top to bottom, is a tiny segment of the lit up raster, then a black space, another lit up segment, another black space, on and on. Now, the horizontal line of our "+" is perfect: It's one, solid, lit up line, because there are no spaces in the raster in this direction.

Well, the fact that you can't get high-quality lines in both directions has never really bothered anyone...until...the X-Y monitor —a completely different type of display. If we created a centered "+" on an X-Y monitor, it would look like this:

X-Y monitor

Nice Lines
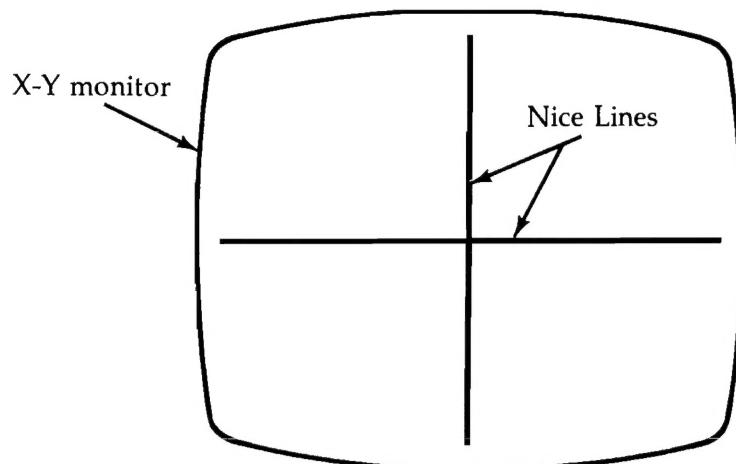
We would see two perfect, solid lines—no gaps anywhere. How does this happen? The reason is that there is NO RASTER in the X-Y monitor—none at all. What creates the high-quality, solid lines in any direction in an X-Y monitor is the electron-beam inside its CRT*. Unlike the beam in the raster-scan unit, the X-Y beam can be moved in any direction we want. All we have to do is figure out *where* we want to move it, and then move it. It's like being able to move the light beam from a high-intensity advertising beacon all over the sky from one position on the ground. Of course, it's not quite as carefree as that, because we must tame the beam to behave as we want. We need to tell the beam when to turn on, or intensify, to "draw" the design we want, how big to make the design, what color the lines should be, what angles the lines will take, and when to stop drawing. More about this later. For now, remember that we are directly influencing the X-Y beam to create our lines by moving it and turning it on when necessary; in the raster-scan, all we had to do was turn on the beam at the right times.

Important differences between the raster and X-Y monitors are that the X-Y's have no need for vertical or horizontal oscillators and drive circuits, since these pre-determine the electron-beam's movement. Also, no flyback pulse is needed in the X-Y to move the beam to the top of the raster. However, a very high voltage is still necessary in the X-Y to attract the electron-beam to the front surface of the tube.

Before we delve into the circuits that make up the color X-Y monitor, let's consider how we actually control an electron-beam. Inside the picture tube neck, there is a piece of metal called a CATHODE. When it is charged with a

**The X-Y Electron-Beam**

Controlling The Electron-Beam

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*In both the color X-Y and color raster monitors, there are actually three electron-beams, one for each of the three colors, red, green and blue. For now, it's easier to think of just one electron-beam. More on the color beams later.

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voltage, it generates electrons. As the electrons are emitted, they are shaped to form a thin ray, or beam, that strikes the front of the monitor. The only way the beam will move up or down, left or right is if a magnetic field is applied around the beam. This is what the DEFLECTION COILS located around the CRT neck do. There are two coils, one to move the beam up or down (VERTICAL DEFLECTION COIL) and one to move it left or right (HORIZONTAL DEFLECTON COIL). So, by running some current through either coil, we create a magnetic field around the beam to deflect it in any direction. The larger the current we put through either coil, the stronger the magnetic field and the more the beam will deflect.

While we're on the subject of beam movement, consider why this monitor is called an "X-Y monitor". Picture our "+" symbol on the screen again; the horizontal line is called the "X" axis and the vertical line is the "Y" axis, hence "X-Y monitor". So, make a mental note that when we move the beam horizontally, we are moving it on the X-axis; moving the beam vertically occurs on the Y-axis. Okay, now let's look closer at the color X-Y monitor circuits and see where this deflection coil current comes from. (For the following explanation, refer to the X-Y monitor schematic in this manual). The circuitry in block A accepts two varying voltage levels, one for Vertical, one for Horizontal, from the G-80 boards. These voltages are called ANALOG signals because they represent all voltage levels between two pre-determined levels.

The Color X-Y Monitor Circuits

Let's say that we want an analog signal that can vary between two voltages, +3 and -3 volts. We could control it to look something like this on an oscilloscope:
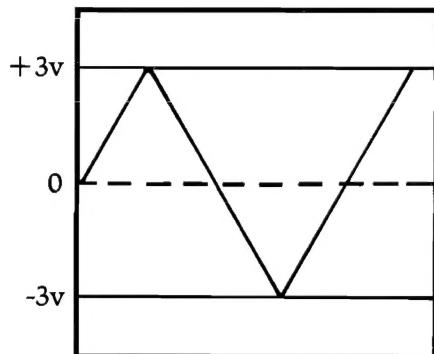
As the signal changes, it moves through all possible voltage levels that exist between +3 and -3 volts. Don't confuse this type of signal with a digital one. The digital signal switches between 0 and, typically, +5 volts. It does not drop to a negative voltage level. As these varying voltages come into the X-Y monitor (Block A), they activate the X and Y power amplifiers, shown in schematic Blocks B and F, respectively. These amplifiers control the amount of current that flows into the X and Y deflection coils, depending on the voltage levels on the inputs. Remember, this current controls the electron-beam movement, so, if we vary the input voltage, we vary the output current AND the direction of the beam. The following chart will clarify this:

	INPUT VOLTAGE	BEAM MOVEMENT
Y-AMP (Vertical)	POSITIVE NEGATIVE	UP DOWN
X-AMP (Horizontal)	POSITIVE NEGATIVE	RIGHT LEFT

Earlier, we said there has to be a way to turn on, or intensify, the electron-beam to create an image on the screen. Well, there are three more inputs to the color X-Y that allow us to do just that: They are the inputs labelled RED, GREEN and BLUE on the schematic, and they accept ANALOG signals from the G-80 hardware. These color signals activate the three color electron-beams through the circuit in schematic Block C. Keep in mind that because these signals are analog, we can vary them to increase or decrease the intensity of the color beams and therefore vary the color on the screen. For example, turning all three signals full-on produces a white display.

Using what we know so far, let's apply it to an actual example of drawing something simple on the screen—a white line, for instance:
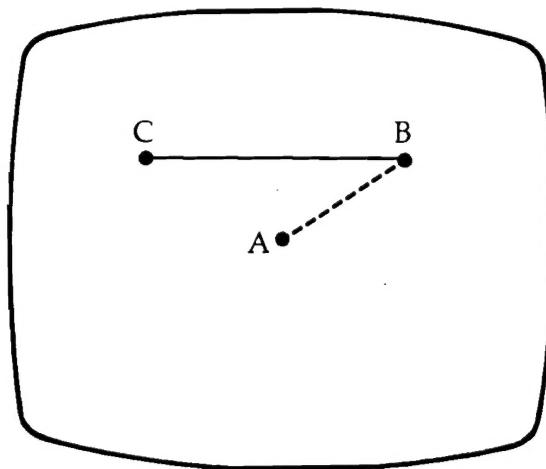
Point A, the center of the screen, is the starting point for the electron-beam. To move the beam to point B, we have to supply voltages to the monitor's inputs that cause the beam to move at a 45 degree angle. To do that requires two increasing positive voltages on the horizontal *and* vertical inputs. (See the chart above). Not only are these voltages positive in this case, they also have to be equal. And, if they are equal, the deflection coils will force the beam the same distance upward and the same distance to the right AT THE SAME TIME. Moving at any other angle is just a matter of making one coil deflect more or less than the other. But note that both coils force the beam AT THE SAME TIME.

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Since we don't want this 45 degree line to show up on the screen, we don't feed any voltages to the RGB inputs. But, we know the beam is at point B, awaiting further deflection. Now, we cause the voltage on the horizontal (X) input to go negative and leave the vertical voltage where it is. Also, we turn on the RGB inputs to give us a white line. From the chart, you can see that these voltages will cause the beam, to move to the left, horizontally, to point C. Now, we have our line. Here is what our input signals looked like during this process:

Horizontal (X) Voltage
+V
0
-V

Vertical (Y) Voltage
+V
0
-V

R
G }
B
+V
0
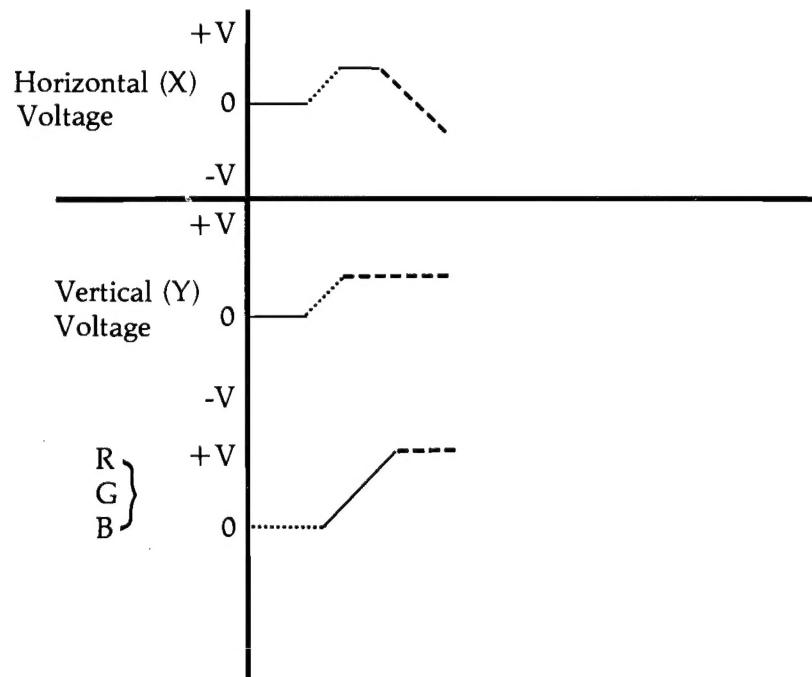
In our example, we made a very short line, considering we could have drawn one clear across the screen. In order to draw longer lines, in any direction, we simply increase the positive or negative voltage on the inputs. Remember—the higher the voltage, the more the deflection, the longer the line.

The remaining circuits in the monitor are a power source (block E), the CRT and brightness adjustment (block D) and the high-voltage generator (block G). Here is a block diagram of a basic X-Y color monitor:

COLOR X-Y MONITOR
BLOCK DIAGRAM

DEFLECTION
COILS (YOKE)

R

G   0-4 v

B

CRT

FEEDBACK

HV
22.5kv

ERROR-
AMP

Y-AMP

VERTICAL
±3v

FAIL

FEEDBACK

X-AMP

HORIZONTAL
±4v
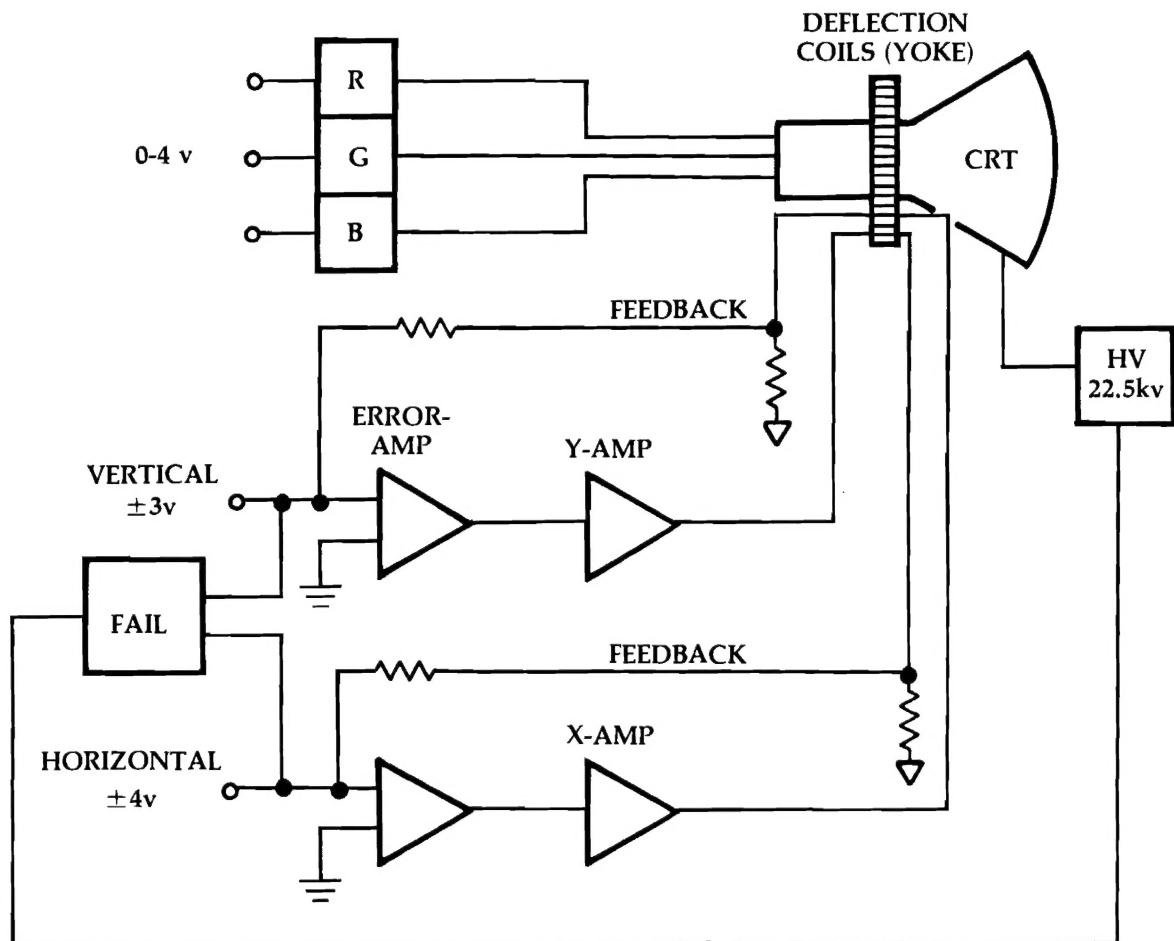
THE COLOR X-Y MONITOR CIRCUITS, DETAILED

Refer to the X-Y schematic for the following discussion of the monitor's operation. The circuitry in schematic block A serves two purposes. First, it compensates for a type of distortion known as pin-cushion distortion. This occurs because the electron-beam must travel a greater distance when striking the edges of the CRT than when it hits the center. If we cause the beam to trace along the edges of the CRT, the beam would draw a box with its left and right sides bowed inward. To compensate for the effect, this circuit offsets the point where the beam would normally strike the CRT surface.

Secondly, this circuit contains two error amplifiers, one for the horizontal and one for the vertical inputs. Each error amp has two inputs; one is set to zero volts, the other accepts the analog signal from the G-80, and senses current movement in the deflecton coil. The analog signal is allowed to pass through the error amps and drive the deflection (power) amps. The deflection amps are shown in blocks B and F. The outputs of the X and Y power amps pass current through their respective deflection coils. Now, the output leads of the two coils are connected back to the analog inputs of the respective error amps, as mentioned above. This acts as an error, or feedback, signal and ensures that the current through the deflection coil remains proportional to the voltage on the error amp inputs. If this signal were not provided, there would be a slight deflection error when an analog input signal was present.

The outputs of the X and Y deflection amps can swing between +60V and -60V. This voltage is high enough to provide up to 8 amps, peak-to-peak, of current through the deflection coils.

Color drive circuits are located in schematic block C and they accept a 4 volt maximum signal on the RGB inputs. The outputs drive the three electron-beams in the CRT. Three neon glow bulbs, NE-100, 101 and 102, act as spark arrestors for the color-drive outputs to the CRT. In block D, the CRT is shown, as well as the brightness adjustment for it. The circuit of D409, R412, R411, R410 is a spot-killer that prevents the electron-beams from burning a "hole" in the phosphor surface of the CRT when the monitor is turned off. Section G of the schematic consists of the high-voltage oscillator in IC 14-2155-01 which operates the HV transformer, T901. This transformer is technically a flyback type, but it is not used to deflect the beam. The IC serves two other functions: It senses the presence of the 10.3KV through R921 and R932 and compares it against the 9.1 supply voltage to ensure a regulated output. Also, this circuit senses the presence of varying current in either deflection coil. If no change is detected, the IC shuts down the high-voltage oscillator to prevent the beam from "burning" the front of the CRT.

Finally, the X-Y power supply is shown in block E; it generates the following voltages:

±60V	to X-Y power amplifiers
+55V	to RGB video drivers and spot killer
±9.1V	to ICs
+120V	to flyback (EHT) oscillator

A degaussing circuit is provided through D404, D405, and R400. The CRT is automatically degaussed when R400 is cooled sufficiently to conduct current through the degaussing coil.

THE G-80's ROLE

It's not hard to imagine how fast the input signals to the color X-Y monitor must be changing in order to produce fantastic X-Y game displays. It's also not hard to understand that a computer must be making all this happen. That is exactly the case with the G-80 hardware used in the color X-Y games. It contains two new boards, X-Y TIMING and CONTROL, that produce the X-Y monitor input signals. The G-80 still relies on its CPU, EPROM, SOUND and SPEECH boards to complete the computer.

Digital-Analog Conversion

But what does a digital computer have to do with producing the analog signals required by the X-Y monitor? Basically, the computer converts certain digital signals into analog ones. On the G-80 X-Y boards are circuits (some are actually ICs) called Digital-To-Analog converters, D/A for short. These circuits accept a particular digital word, that is, a string of 0 and +5 voltage levels. The D/A converter senses the word and outputs one and only one voltage level which corresponds to the digital word. For example, we could design a simple D/A converter that would generate the following voltages when we input certain digital words:

DIGITAL WORD	ANALOG OUTPUT
0000	-1 VOLT
1111	1 VOLT
1000	0 VOLT

This is a very basic case, but it shows that, for a particular D/A converter, we always produce one voltage level from the corresponding digital input. If we cycle through a variety of digital inputs, we'll get a variety of output voltages. If we do this fast enough, we actually create a rapidly varying range of output voltages. This output is exactly the kind of signal we need to drive the deflection coils in the monitor.

Now we know where the analog signals come from. What about the digital ones? What is their role in the X-Y system? Here's what happens:

Before we can display anything on our X-Y screen, we have to ask some questions: (Answers are provided for example's sake)

QUESTIONS	ANSWERS, FOR EXAMPLE
1. What do you want on the screen?	A triangle.
2. How many?	Just one.
3. What kind of design - What angles will it have?	A triangle with 3 equal sides, or one with 3 60 degree angles.
4. What size, or how long are the lines in it?	Make each side about 3″ long.
5. Where do you want it on the screen?	The center of the triangle should be the center of the screen.
6. What colors do you want?	2 sides white, one blue.
7. How will it be positioned on the screen?	Like this:

BLUE
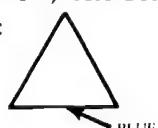
8. What will it do once it's on the screen? — Just sit there.

9. How many lines does the *electron-beam* have to make to create the design? — In our triangle, the beam must make 4 lines:

D / A \ B
C
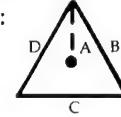
A (even though we won't see it), B, C, and D.

Now that we have all our specifications, we have to store this information someplace so the Timing and Control boards can get to it and understand it. That place is video memory RAM. (See the Block Diagram). It holds 4096 8-bit words or bytes. Of course, we don't stick all this into video memory and hope the X-Y boards find it. We store the information in an orderly fashion.

First, we divide the video memory into two main groups—let's call them 1) The Symbol Instructions and, 2) The Line Instructions. Into the Symbol Instructions section, we store one group of ten words for every symbol or design we put on the screen. In our example, we have only one symbol, so we use only 10 words. Into the Line Instructions section, we put one group of four words for every *Line* that the beam has to draw. So, for our triangle, which requires 4 lines, we would store 4 groups of 4 words in the Line Instructions space. Every word we store in memory has one and only one address, so the same word can be called on over and over. Now, let's look closer at the Symbol Instructions memory space. Here is what the 10 words do: (Don't be concerned with actual values of those words right now.)

WORD 1
It tells the X-Y boards either to make the beam draw the symbol in this group of words or not draw it. And, the same word informs the boards that either this group of words is the only group or that there are more 10-word groups to follow.

WORDS 2 AND 3
These tell the boards where the beam is on the X-axis.

WORDS 4 AND 5
These tell the boards where the beam is on the Y-axis. The last four words, then, give the exact coordinates of the electron-beam.

WORDS 6 AND 7
Words 6 and 7 tell the X-Y hardware what the *First* address is of the Line Instructions section.

WORDS 8 AND 9
These tell the hardware how the complete symbol (our triangle) will appear on the screen, or at what angle.

WORD 10
This word tells what the overall size of the design will be.

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Again, since we're only making one design, there will be no more 10-word groups after the one above. Now take a look at the Line Instructions section of memory:

GROUP 1

WORD 1   This word tells the G-80 boards either to blank or to unblank the line. And, it informs the boards that either additional 4-word groups follow or no more groups follow. Finally, it defines the color this particular line is to be.

WORD 2   This word represents the length of the line the beam is to draw.

WORD 3   Word 3 tells the hardware at what angle the beam should make its line. 45 degree? 90 degree?

WORD 4   Word 4 defines in which of the four sections of the screen the line is to appear—which quadrant.

The remaining 4-word groups contain the same representations of their respective lines, as in Group 1. The values will be different, of course, depending on how the lines differ. In our triangle example we would find 3 more groups of four words after Group 1.

By now, you may be wondering what all these "words" really are. Since we are dealing with a digital computer, the "words" we described above must be digital. More accurately, they are digital values of the specifications required to create our designs. We have taken the specifications for sizes, angles, shapes, colors and locations and converted them into digital words that the G-80 system understands. Then we let the G-80 read these words and create displays that the words represent.

Before we go any further, you should know that the words read from the video RAM didn't get there by magic. The microprocessor put them there. All the words that represent all the characters and designs in a game are kept safely in EPROM, on the EPROM Board. When the game is powered up the CPU moves the various word groups from EPROM to RAM. Once situated in video memory, the words are made available to the Timing and Control boards to create displays. Briefly, here is what the two X-Y boards do with the words: (Refer to the Block Diagram to locate the circuits discussed).

G-80 Control And Timing Boards Operation

After all the character words are loaded into video RAM, the Program Counter is forced to call on the first RAM address. Here, the Program Counter finds the first word in the Symbol Instructions section. One at a time, these ten words are taken out of RAM and latched into specific parts of the X-Y boards. This sequence is controlled by the Timing Generator which generates 15 active-low signals; only one signal pulses low at a time to latch the words. Next, the following sequences occurs:
1. Word 1 is latched into U52, Last Symbol block.
2. Words 2 and 3 (from the Symbol Instructions) are loaded into the X-axis Up/Down counters.

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3. Words 4 and 5 are loaded into the Y-axis Up/Down counters.
4. Words 6 and 7 are stored in the Vector Address counter.
5. Words 8 and 9 are stored in the Symbol Angle latch.
6. Word 10 is loaded into the Serial Multiplier.

Now the first 10 words of a character we wish to display are stored somewhere. If we had not wanted to draw this character, the Program Counter would have jumped to the next set of 10 symbol words, if there were another symbol. Once the Program Counter is finished moving out the words, the Vector Address counter takes control of memory. This switching between the Program and Vector Address counters is governed by the Multiplexer. Through it, the G-80 Address Bus or one or the other counter can address video memory. Only one device is allowed access to memory at a time. When it is the Vector Address counter's turn to get into memory, the counter addresses the first word of the Line Instructions section. The reason for this, is that the Vector counter was previously loaded with words 6 and 7 in the Symbol Instructions section. These words tell the Vector Address counter the locations of the first word in the Line Instructions section. Now the Vector counter causes the Line Instruction words to be moved out of memory, one at a time. Here is what happens to the group of four words:
1. Word 1 is stored in the Color Latch and in U52, Last Vector.
2. Word 2 is stored in the Vector Length counters.
3. Word 3 is loaded into the Vector Angle circuit.
4. Word 4 is used in the Vector Angle circuit.

Up to this point, then, 10 words that describe some symbol and 4 words that represent *one line* in that symbol have been clocked out of memory. When the Vector Address counter takes out the last group of words that represents the last line to be drawn, memory access is switched back to the Program Counter. It will now either restart the sequence as before (if there is another symbol to be drawn) or it will stop until the counter is reset to the beginning again.

Drawing The Line

Now the system is ready to draw its first line, to actually move the beam, because we have given it exact specifications to do so. The position of the electron-beam is now known, (Words 2 through 5 in the Symbol Instructions) so, we know where the beam will start to draw. Then, the X-Y boards calculate the length and angle of our first line. And, they know the color, if any, of this line. (In our triangle, remember, our first line, A, is the one we don't actually see, but it must be drawn. We also know that it must be drawn at a 0 degree angle—straight up.) The boards calculate the line length and angle by assigning a certain number of digital clock pulses to these qualities: The circuitry acts as a digital "ruler" and "protractor" and measures any line, in terms of how many pulses in length and angle it is. All this figuring is performed by the Full Adder's, 2708 EPROM and Rate Multipliers. The output of each Rate Multiplier (XCL and YCL) is a string of clock pulses that clock the respective Up/Down counter, X or Y. But the pulses are not just random pulses: *They are the digital equivalents of a line with a particular length and angle.* So, we clock both Up/Down counters at the same time with these meaningful pulses. Doing so, we force the counters to start counting *from the beam position words* previously stored in the counters. The important point is this: If we change the *digital* values of the beam position words, *we change the position of the beam* through the D/A converters. *How far* and at *what*

angle we change the beam depends on the *amount of pulses* applied to the Up/Down counters. Just before the beam is moved, the color of the line (black, included) is sent to the monitor through the RGB D/A converters.

There you have it—one line. For more lines, the G-80 system rapidly follows the same procedure of reading the symbol and line words, latching them, calculating line values, color values, and then forcing the beam line-by-line to form complete symbols.

The CPU's Role   Notice that throughout our discussion, we have mentioned the microprocessor's role just once: It loads the character words into memory. During an actual game, however, it does more than act as a "loader". Whenever we want to move our symbols on the screen, for example rotate the triangle, we need some way of changing all those words to represent new lines and angles. Well, the CPU fulfills this job perfectly. Under program control, the CPU is told when and how to alter these words to create a whole range of dynamic displays—different colored lines, new angles, longer or shorter lines, bigger or smaller characters, whatever the game play calls for. Also, the microprocessor governs all game functions such as player control and coin inputs, or sound and speech outputs. The CPU, then, gives us the variety and color in the X-Y games.

G-80 CONTROL AND TIMING BOARDS OPERATION, DETAILED

Note: Designations in parentheses will be used throughout this discussion to refer the reader to the proper schematics. C = X-Y Control Board #800-0163, sheets 5 and 6. T = X-Y Timing Board #800-0161. sheets 5, 6 and 7. e.g. (C6) = Control Board, sheet 6.

The CPU addresses video memory, U24-U31, through multiplexer ICs U48 and U49 (C5). Character words are taken from memory as the Program Counter, ICs U33, U34, U22 (C5), addresses them through multiplexers U36, U49, U35, and U21 (C5). If Word 1 (Symbol Instructions) says to not display a symbol, the Program Counter is advanced 10 counts by U33, a full adder, which adds 10 to the counter when signal ADD goes low. The Vector Address counter is composed of U10, U11 and U12 (C5) and is loaded with the first address of the Line Instructions from video memory's Character Data Bus, CD0-CD7. The CPU's Data Bus, D0-D7, is brought to the memory through a bi-directional buffer, U14 (C5). The signal labelled FETCH (C5) latches the various Character Data words from memory. The MUX (C5) signal commands the multiplexer ICs to allow either the CPU, Program Counter or Vector Address counter to address memory. MEMR (memory read) and MEMW (memory write) come from the CPU board to read from or write to the RAM. Signal VCE (C5), Vector Clock Enable, increments the Vector Address counter. PCC (Program Counter Clock) is the string of pulses that advances the Program Counter; PCR (Program Counter Reset) ensures that the Program Counter starts counting at the first location in video RAM each time PCR goes low. This signal occurs first at power-up and then 40 times a second during program execution. So, it causes the X-Y monitor to draw and re-draw each symbol on the screen 40 times a second. The signal is generated from the master clock (crystal Y1 and U14, T7) by U31-U34 and U22 (T7). The other clock signals (VCE, PCC, FETCH, ADD, MUX, and VCL) are all generated by the X-Y timing board (T7).

The outputs of the Last Symbol and Last Vector latches (U52, T7) are AND'd together with the signal END, which originates from the Control Board's U18 (C6). When U18's output goes low, it signifies that no more symbols are to be drawn. Then, the Program Counter is reset by the 40 HZ signal to the start of the video memory to repeat the display sequence. U22 (T7) is the DRAW latch and its output, through U21, creates the DRAW signal which initiates a sequence that causes the beam to draw. This sequence occurs on the Timing Board, sheet 6: By this time, all video words have been stored in their proper places in the system. On the Timing Board (T7), the vector angle is in U56, the symbol angle in U55. So, when DRAW goes high, it causes strings of digital pulses that represent the vector and symbol angles

to be generated. These streams of pulses (from U28, T6) are the ones that clock the X and Y Up/Down counters, shown on T5 (U15-U20). U25 (T6) tells the counters in which direction to count, up or down (D/UX, D/UY). Then, the outputs of the Up/Down counters, X and Y, become the digital words that are converted to analog signals by D/A converters U1 and U4 (T5). Op Amps U2 and U3 (T5) convert current from the D/A converters to voltage levels. These levels drive the Vertical and Horizontal inputs to the monitor. Signals DRAW and VCL are combined in U28 (T6) to form DCL (Draw Clock). This signal clocks down the Vector Length counters U15, U16 and U17 (C6) which contain words that represent various lengths of the lines to be displayed. When the counters have counted down to 0, the END signal becomes active. As the X and Y Up/Down counters are clocked, their outputs are sensed by U5-U10 (T5), which are multiplexers. The multiplexers are necessary to tell the system when the beam is off the screen. It does this by generating the BOS signal (T5). Then BOS is AND'd with DRAW at U5 (C6) to blank (turn off) the beam whenever BOS goes low.

U3 (C6) compensates for the inherent delay in deflecting the electron-beams. It provides a number of taps to select a range of delay times. From U2 (C6), the color word is read and applied to the RGB D/A converters U5, U1 and associated diodes and resistors. The RGB outputs go directly to the color X-Y monitor.

U50, a 74LS154 (T7) decoder IC, selects one of 15 outputs by making the output low. The outputs sequentially store the video memory words, one at a time, in various parts of the X-Y boards. Only one output is allowed to go low at a time. U50 is enabled at pin 18, forty times per second by U22 (T7), and at pin 19 by U21. U51 sequences U50 through its 15 count cycle; at count 14, pin 16 of U50 goes low to initiate the DRAW signal through U40, U21 and U22 (T7).

The circuitry at the top of schematic C6 (U45, U51-U54) is not used in generating and displaying characters on the X-Y monitor. Its function is to perform lengthy calculations under software control.

TROUBLESHOOTING AND ADJUSTMENTS

NOTE: For instructions on the built-in SELF-TEST, refer to the Game Manual Troubleshooting section.

Introduction

Essentially, any repair procedure consists of isolating a problem first to one or two major game components—the monitor, for example. From there, we eliminate more possibilities by isolating one or two faulty circuits; then eliminate to the faulty component level. In the Color X-Y system, we are dealing with 3 major game components:
1. The Power Supply
2. The G-80 Set of Boards
3. The Color X-Y Monitor

So, in a typical maintenance procedure, we would first attempt to determine which of the 3 major elements is defective. In the following sections, we will look at each element and some of its sub-divisions as a guide in isolating problems.

Power Supply

NOTE: Power Supply schematics are in the Game Manual.

Usually, the power supply can be eliminated as the source of a problem if the game comes up on the screen. The major exception is when the game plays normally but no game sounds are produced. In this case, the power supply's amplifier circuit should be checked for audio signals from the sound and speech boards. If they are present on the amplifier output, then a bad speaker or connection is probably the cause of the problem. If the signals are not there, suspect the amplifier circuits on the sound and/or speech boards.

If the picture does not appear on the screen, check the power supply for the main AC voltage to the primary of its transformer; then, ensure that the G-80 boards are supplied with the correct DC voltages from the power supply. Also make sure the 3 VAC reset signal is being applied to the CPU board. If all these tests prove normal, then eliminate the power supply as cause of the problem and proceed to check the remaining game components—G-80 boards and monitor.

G-80 Boards

NOTE: Schematics for CPU, EPROM, SOUND, and SPEECH Boards are in the Game Manual

In most cases, a simple test will help to isolate a problem of no picture to either the G-80 boards or the monitor. On an oscilloscope, look for varying voltage signals on pins 1 and 4 of the 4-pin Molex connector on the Timing Board. If the signals look similiar to those shown in Figure 1, check for signals swinging between 0 and +4 volts on the R, G, B outputs (4-pin Molex connector pins 4, 1, 2 respectively) on the Control Board. If all three outputs are at 0 volts, suspect the X-Y boards. If the signals appear normal, suspect the monitor as the cause of the problem. If, however, pin 1 (to the monitor's Horizontal Input) is held at or near +4 or -4 volts DC, suspect one or both X-Y boards. If pin 4 (to Vertical Input) is held at or near +3 or -3 volts, suspect the G-80 boards. In either case, TURN OFF THE POWER AND IMMEDIATELY DISCONNECT THE X-Y MONITOR. Proceed to check the

inputs to D/A converters U1 and U4 (T5) for active signals. Verify that none of the Character Data lines (CD0-CD7) are pulled high or low, or are floating. Check for the XCL and YCL clock signals from U28 (T6). Verify that the 15 MHZ crystal clock is operating and that a 40HZ signal is present on pin 11 of U13 (T7). Check BOS signal to be sure it is not held low; signal DRAW should be switching high and low. On the Control Board, observe the signal FETCH to ensure it pulses high and low. Also, none of the Data lines (D0-D7) should be held high or low, or floating (C5). Check for clock signals PCC and SCL (C5). Look for input changes on U1 and U5 of the color circuit (C6); also, pin 3 of U4 should be active high and low.
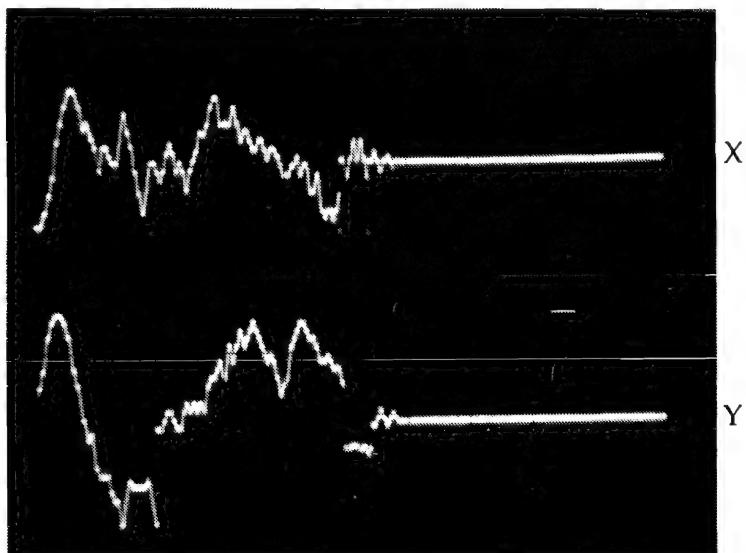
Figure 1

Color X-Y Monitor   When the X-Y monitor is suspected with a problem, check for all correct power supply voltages as shown in the schematic. Isolate incorrect voltages to either the monitor power supply or to the circuit receiving the voltage. **NOTE: The color X-Y monitor contains a circuit that shuts off the high-voltage oscillator when no vertical or horizontal inputs are present.** DO NOT ATTEMPT TO RAISE OR LOWER EITHER INPUT WHEN TESTING THE MONITOR. DOING SO WOULD CREATE EXCESSIVE DEFLECTION CURRENT THAT COULD SEVERELY DAMAGE THE MONITOR. For testing the monitor, use **only** the outputs of the G-80 hardware. In addition, DO NOT operate the monitor WITHOUT proper fuses in the main AC line. If a monitor is causing the main fuse to blow, proceed to check the deflection amplifiers' power transistors Q605, Q606, Q705 and Q706, WITH THE POWER OFF. Also, check for a shorted transistor or diode in the deflection amplifiers (POWER OFF).

Check the transistors in the color drive circuits for shorts or opens when one or more colors is missing in the picture and the G-80 boards are known to be good.

ADJUSTMENTS

G-80 Boards On the X-Y Timing Board, there are two pots, R3 and R6, that adjust the outputs of the X (R3) and Y (R6) current-to-voltage converters U2 and U3.

Color X-Y Monitor On the monitor, there are a number of factory-set adjustments. Do not use these controls. They are:

R702	WIDTH	R920	
R611	HEIGHT	R106	GAIN
R917		R117	GAIN
R918			

The following controls can be used to adjust the monitor, if necessary:

R605 (vert) and R712 (horiz)	Center picture on the screen
R107 (red), R118 (green), R136 (blue)	Adjust color of picture
R930	Adjusts brightness of picture
R922	Focuses picture

Color X-Y Monitor Input Specifications

Vertical Input	$= \pm 3$ V max.
Horizontal Input	$= \pm 4$ V max.
Red Input—Full Brightness	$= +4$ V
Green Input—Full Brightness	$= +4$ V
Blue Input—Full Brightness	$= +4$ V

Parts Catalog

MONITOR REPLACEMENT PARTS LIST

Note: Call SEGA/Gremlin Customer Service for availability of these parts and for part numbers.

EHT SUPPLY ASS'Y G08-001 02-170003-01
SEMICONDUCTORS

SYMBOL	DESCRIPTION
IC900	EHT Control Circuit
ZD900	200V Zener Diode
ZD901	200V Zener Diode
D900	Rectifier 1A. 1400V
D901	Rectifier 1A. 1400V
Q901	Transistor TIS93
Q902	Transistor TIS92

TRANSFORMERS

T900	Horiz. Buffer Trans.
T901	Horiz. Output Trans.

COILS

L900	Horiz. Delay Choke
L901	Flyback Load Coil
L902	RF Choke 27UH

CAPACITORS

C900	Electrolytic 4U7 16V
C901	Electrolytic 4U7 16V
C902	Capacitor .22uF 50V
C903	Ceramic Capacitor IN5/50V
C904	Electrolytic 22uF 16V
C905	Electrolytic 22uF 16V
C906	Ceramic Capacitor
C907	Capacitor 47N 100V
C908	Capacitor 47NF 400V
C911	Electrolytic 100uF 16V
C912	Capacitor 100NF 100V
C914	High Current Capacitor
C915	High Current Capacitor
C916	Capacitor 10uF 250V
C917	Capacitor 10NF 1000V
C918	Capacitor 47NF 100V
C919	Electrolytic 470 uF 16V
C920	Capacitor 2N2 3KV
C921	Capacitor .22uF 50V

RESISTORS

R900	10K .25W 5%
R901	10K .25W 5%
R902	47K .25W 5%
R903	47K .25W 5%
R904	150K .25W 5%
R905	12K .25W 5%
R906	10K .25W 5%
R907	4K7 .25W 5%
R908	470K .5W 5%
R909	470K .5W 5%
R910	470K .5W 5%
R911	2K7 .25W 5%
R914	620R .25W 5%
R915	10K .25W 5%
R916	150K .25W 5%
R917	200R Control
R918	2K Control
R920	20K Control
R921	HV Safety Res. 200M $\pm$ 10%
R923	270R .25W 5%
R924	470R .25W 5%
R927	33R .25W 5%
R928	390K .5W 5%
R929	390K .5W 5%
R930	68R .25W 5%
R931	100K .25W 5%
R932	180K .25W 5%

EHT SUPPLY ASS'Y KIT 05-170004-01

Q900	PWR Transistor 5A. 1400V
R922	Focus Control

C.R.T. P.C.B. COMPONENT LAYOUT
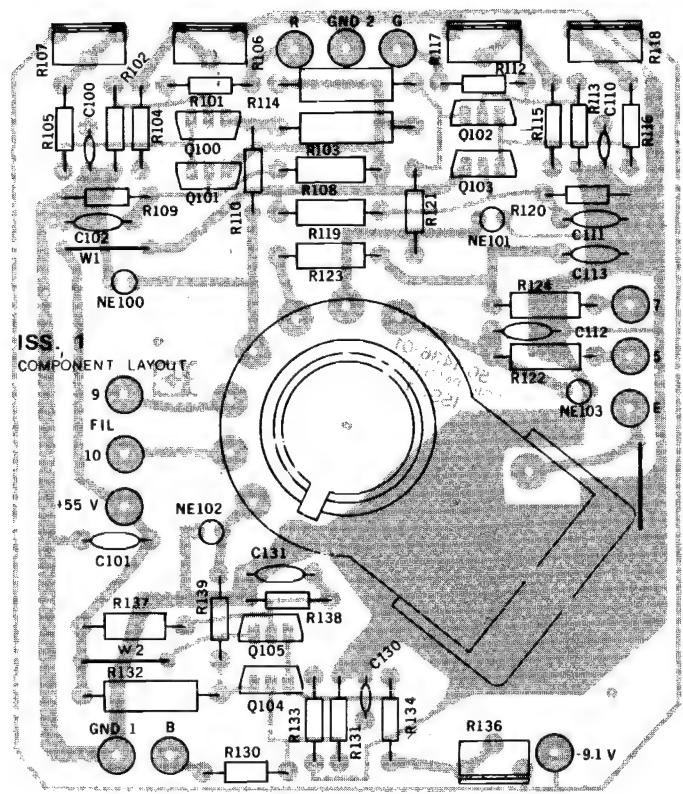
EHT P.C.B. COMPONENT LAYOUT

24
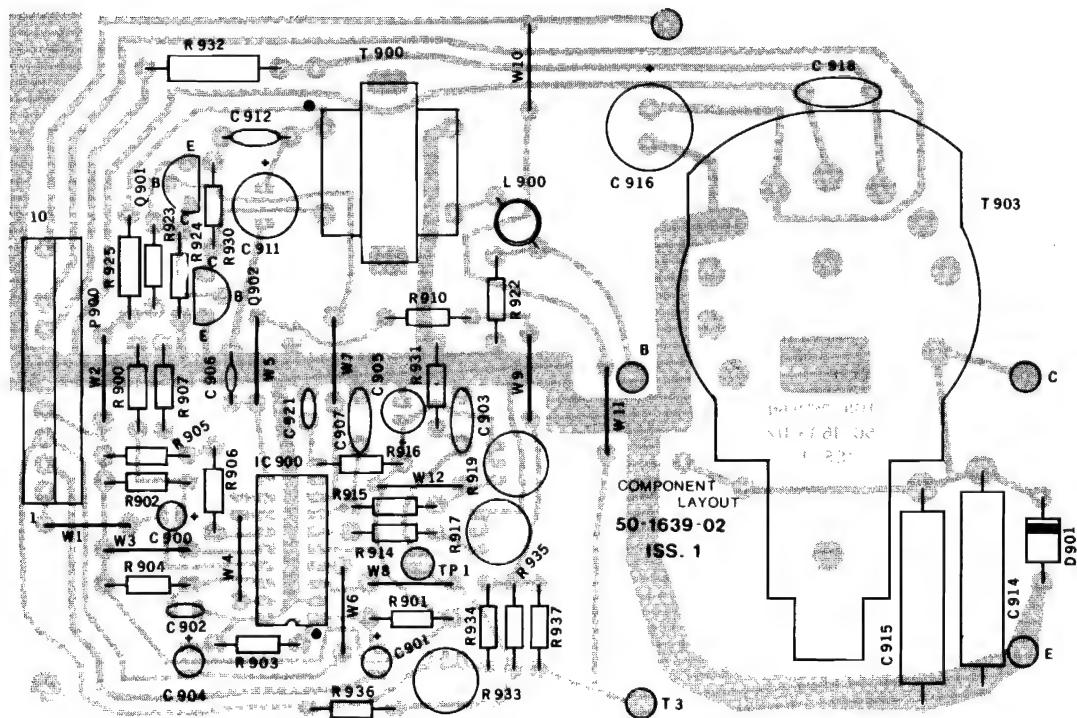
DEFLECTION AMP PCB ASS'Y 02-170005-01
SEMICONDUCTORS

SYMBOL	DESCRIPTION
IC600	Input Amplifier IC
D400	Rectifier 6A 200V
D401	Rectifier 6A 200V
D402	Rectifier 6A 200V
D403	Rectifier 6A 200V
D404	Rectifier 1A 200V
D405	Rectifier 1A 200V
D406	Rectifier 1A 200V
D407	Rectifier 1A 200V
D408	Diode TI IN914
D410	Rectifier IN4003
D601	Diode TI IN914
D602	Diode TI IN914
D603	Diode TI IN914
D604	Diode TI IN914
D605	Diode TI IN914
D701	Diode TI IN914
D702	Diode TI IN914
D703	Diode TI IN914
D704	Diode TI IN914
D705	Diode TI IN914
ZD400	Zener Diode IN5263B .5W 56V
ZD401	Zener Diode IN5239B .5W 9.1V
ZD402	Zener Diode IN5239B .5W 9.1V
Q400	Transistor TIB 29B
Q401	Transistor TIB 29B
Q600	Transistor MPSU60
Q601	Transistor 300V .5A
Q602	Transistor MPS U10
Q603	Transistor MPS U10
Q604	Transistor 300V .5A MPSU60
Q701	Transistor 300V .5A MPSU60
Q702	Transistor MPS U10
Q703	Transistor MPS U10
Q704	Transistor 300V .5A MPSU60

CAPACITORS

C400	Capacitor 150NF 10% 400V
C401	Capacitor 1000uF 80V
C402	Capacitor 680uF 160V
C403	Capacitor 6800uF 80V
C404	Capacitor 6800uF 80V
C405	Capacitor 10uF 25V
C406	Capacitor 10uF 25V
C410	Capacitor 100NF 200V
C411	Capacitor 22uF 250V
C601	Capacitor .1uF 50V
C620	Capacitor 100pF 10% 500V
C621	Ceramic Capacitor .1uF 50V
C622	Capacitor 47pF 10% 500V
C624	Capacitor .068uF 200V
C701	Capacitor .1uF 50V
C720	Capacitor 100pF 10% 500V
C721	Ceramic Capacitor
C722	Capacitor 47pF 10% 500V
C724	Capacitor .068uF 200V

RESISTORS

R400	Thermistor 120V 60R
R401	33R 4W 10% WW
R402	22K 1W 10%
R403	2K2 .25W 5%
R404	220R 10W
R405	8K2 .5W 5%
R406	680R 6W
R410	4K7 .25W 5%
R411	2M7 .25W 5%
R412	1M .25W 5%
R600	470R .25W 5%
R601	910R .25W 5%
R604	30K .25W 5%
R605	50K Trim Pot
R606	100K .25W 5%
R607	2K4 .25W 5%

25

X-Y P.C.B. COMPONENT LAYOUT
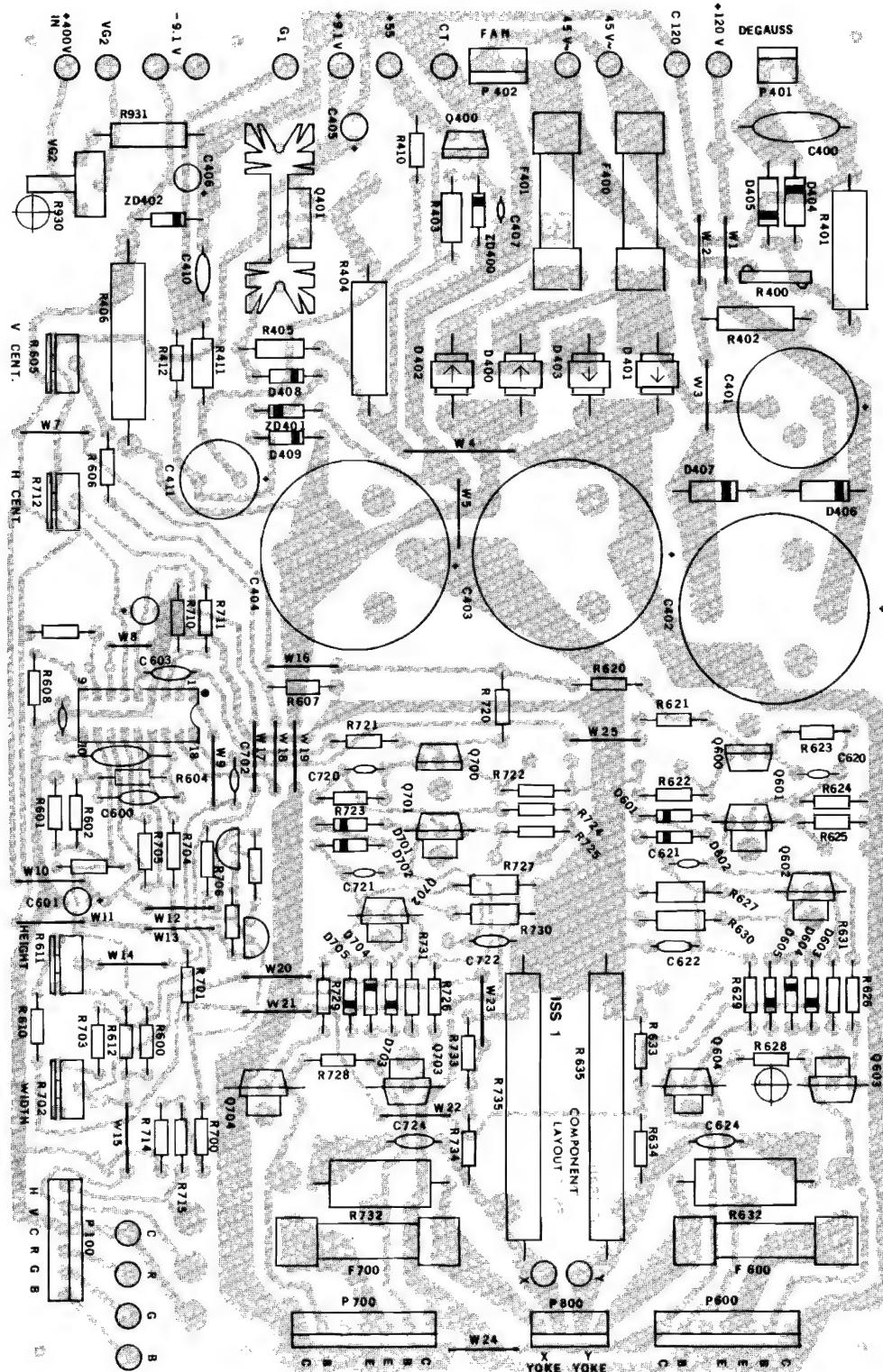
DEFLECTION AMP PCB ASS'Y CONT'D
RESISTORS CONT'D

SYMBOL	DESCRIPTION
R608	15K .25W 5%
R610	4K7 .25W 5%
R611	1K Trim Pot
R612	4K7 .25W 5%
R621	6K2 .25W 5%
R622	180R .25W 5%
R623	22K .25W 5%
R624	1K8 .25W 5%
R625	180R .25W 5%
R626	100R .25W 5%
R627	18K .5W 5%
R628	270R .25W 5%
R629	100R .25W 5%
R630	22K .5W 5%
R631	180R .25W 5%
R632	470R 2W 5%
R633	150R .25W 5%
R634	82R .25W 5%
R635	1R5 10W
R700	2K2 .25W 5%
R701	2K2 .25W 5%
R702	5K Trim Pot
R703	15K .25W 5%
R704	22K .25W 5%
R705	22K .25W 5%
R706	15K .25W 5%
R710	2K4 .25W 5%
R711	100K .25W 5%
R712	50K Trim Pot
R714	1K5 .25W 5%
R715	1K .25W 5%
R721	5K6 .25W 5%
R722	180R .25W 5%
R723	22K .25W 5%
R724	1K8 .25W 5%
R725	180R .25W 5%
R726	100R .25W 5%
R727	18K .5W 5%
R728	270R .25W 5%
R729	100R .25W 5%
R730	22K .5W 5%
R731	180R .25W 5%
R732	390R 2W 5%
R733	150R .25W 5%
R735	1R5 10W
R930	2M Trim Pot
R931	1M1W 10%

FUSES

F400	5A Slow Blow
F401	5A Slow Blow
F600	4A Slow Blow
F700	4A 125V Slow Blow

CRT SOCKET PCB ASS'Y 02-170006-01
SEMICONDUCTORS

SYMBOL	DESCRIPTION
Q100	Transistor MPS u10
Q101	Transistor MPS u10
Q102	Transistor MPS u10
Q103	Transistor MPS u10
Q104	Transistor MPS u10
Q105	Transistor MPS u10

LAMPS

NE100	Lamp
NE101	Lamp
NE102	Lamp
NE103	Lamp

CRT SOCKET PCB ASS'Y CONT'D
CAPACITORS

SYMBOL	DESCRIPTION
C100	Ceramic Capacitor 100pF
C101	Capacitor 10NF 10% 500V
C102	Capacitor 10NF 10% 500V
C110	Ceramic Capacitor 100pF
C111	Capacitor 10NF 10% 500V
C112	Ceramic Capacitor 10NF 1KV
C113	Ceramic Capacitor 10NF 1KV
C130	Ceramic Capacitor 100pF
C131	Capacitor 10NF 10% 500V

RESISTORS

R101	100R .25W 5%
R102	2K7 .25W 5%
R103	3K3 1W 5%
R104	470R .25W 5%
R105	1K6 .25W 5%
R106	250R Trim Pot
R107	2K5 Trim Pot
R108	22K .5W 5%
R109	180K .25W 5%
R110	1K .25W 5%
R112	100R .25W 5%
R113	2K7 .25W 5%
R114	3K3 1W 5%
R115	470R .25W 5%
R116	1K6 .25W 5%
R117	250R Trim Pot
R118	2K5 Trim Pot
R119	22K .5W 5%
R120	180R .25W 5%
R121	1K .25W 5%
R122	220K .5W 5%
R123	1K .5W 5%
R124	470K .5W 5%
R130	100R .25W 5%
R131	2K7 .25W 5%
R132	3K3 1W 5%
R133	620R .25W 5%
R134	1K6 .25W 5%
R136	2K5 Trim Pot
R137	22K .5W 5%
R138	180R .25W 5%
R139	1K .25W 5%

HEAT SINK ASS'Y 02-170004-01

SYMBOL	DESCRIPTION
Q605	Power Transistor
Q606	Power Transistor
Q705	Power Transistor
Q706	Power Transistor
M01	Motor Blower Fan

MISCELLANEOUS

V01	Pix Tube
DY01	Deflection Yoke
L100	Degaussing Coil
J101	Pix Tube PCB Socket
X	Yoke Wedge

X-Y Timing Board Assembly

Item #	Gremlin Part #	Description	Ref Des
1	151-0005	CAP CER 680pf 50v	C7
2	151-0058	CAP .01 uf 16v AX	C1-C3, C6, C8-C28
3	170-0218	PC BOARD	
4	211-0008	CONN PIN TEST PT	TP1
5	212-0101	CONN 4 PIN M RTA	
6	213-0001	SKT 24 PIN DUAL INLN	XP1, XU39
7	213-0004	SKT 16 PIN DUAL INLN	XU1, XU4
8	213-0010	SKT 8 PIN DUAL INLN	XU2, XU3
9	230-0009	XTAL 15.46848	Y1
10	280-0330	CARD EJECTOR	
11	313-0004	IC LM 741 EN DIP	U2, U3
12	313-0044	IC AD561	U1, U4
13	314-0018	IC 74LS00	U28
14	314-0019	IC 74LS04	U30, U40
15	314-0040	IC 74LS125	U27
16	314-0046	IC 74S04	U14
17	314-0055	IC 74LS244	U54, U57, U58
18	314-0058	IC 74LS08	U13, U21
19	314-0062	IC 74LS74	U25, U26, U42, U43, U52
20	314-0070	IC 74LS86	U29
21	314-0073	IC 74LS175	U35-U38
22	314-0074	IC 74LS191	U15-U20
23	314-0076	IC 74LS157	U5-U10
24	314-0078	IC 74LS02	U53
25	314-0093	IC 74LS374	U48, U49, U55, U56
26	314-0097	IC 74LS161	U31-U34, U41, U51
27	314-0101	IC 74LS283	U44-U47
28	314-0108	IC 74LS107	U11, U22-U24
29	314-0120	IC 74LS154	U50
30	314-0135	IC 74LS11	U12
31	315-0019	IC 2708	U39
32	471-0202	RES 2K OHM ½W 5%	R2, R4
33	471-0331	RES 330 OHM ½W 5%	R7, R8
34	471-0392	RES 3.9K OHM ½W 5%	R1, R5
35	475-0024	POT 1K 10 TURN	R3, R6
36	151-0008	CAP CER .001 uf 50V	C29, C30
37	150-0088	CAP E 10 uf 25V RDL	C4, C5

X-Y Timing Board
800-0161
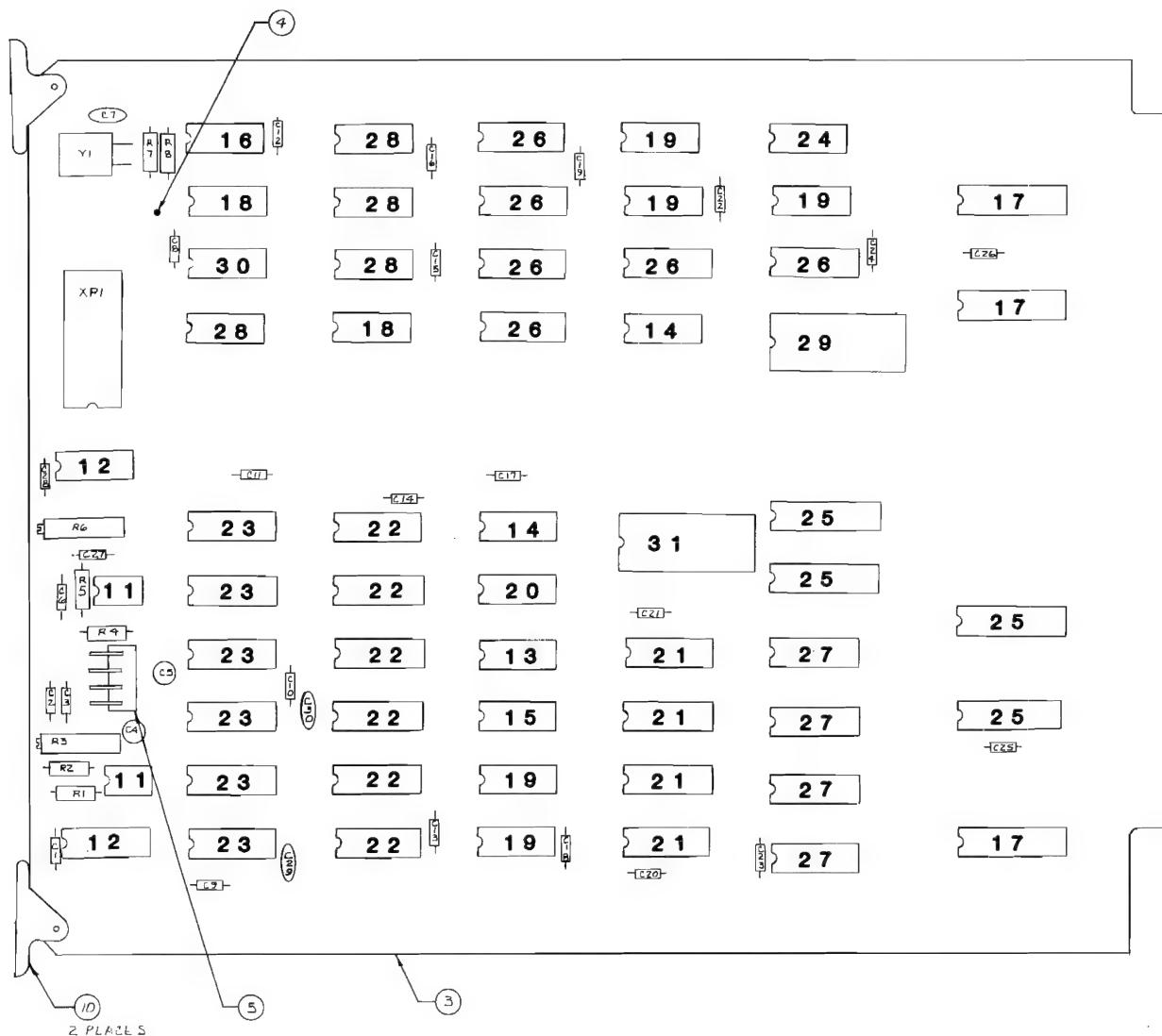
X-Y Control Board Assembly

Parts List

Item #	Gremlin Part #	Description	Ref Des
1	150-0088	CAP E 10 uf 25v	C23
2	151-0002	CAP CER 100pf 50V	C14
3	151-0058	CAP CER .01 uf 16 V AX	C1-C13, C15-C22
4	170-0219	PC BOARD	
5	212-0101	CONN 4 PIN M RTA	
6	213-0001	SKT 24 PIN DUAL INLN	XP1
7	280-0330	CARD EJECTOR	
8	314-0018	IC 74LS00	U40
9	314-0019	IC 74LS04	U9, U32,U42
10	314-0040	IC 74LS125	U39
11	314-0055	IC 74S244	U20, U21, U35, U36, U48, U49, U54
12	314-0058	IC 74LS08	U37
13	314-0059	IC 74LS10	U18, U41
14	314-0060	IC 74LS20	U50
15	314-0062	IC 74LS74	U19, U51
16	314-0067	IC 74LS30	U47
17	314-0068	IC 74LS32	U4, U38
18	314-0074	IC 74LS191	U15-U17
19	314-0075	IC 74LS393	U22
20	314-0078	IC 74LS02	U23
21	314-0087	IC 74LS139	U46
22	314-0093	IC 74LS374	U2,U13
23	314-0097	IC 74LS161	U10-U12, U34, U52
24	314-0099	IC 74LS245	U14
25	314-0101	IC 74LS283	U33
26	314-0108	IC 74LS107	U53
27	314-0127	IC 74LS164	U3
28	314-0128	IC 74LS95	U6, U7, U44, U45
29	314-0137	IC 74LS09	U1, U5
30	315-0046	IC 2114	U24-U31
31	315-0072	IC AM25LS14	U8, U43
32	471-0123	RES 12K OHM ½W 5%	R1, R3, R5
33	471-0472	RES 4.7K OHM ½W 5%	R7, R8
34	471-0622	RES 6.2K OHM ½W 5%	R2, R4, R6
35	481-0006	DIODE IN914 / IN4148	D1-D6

X-Y Control Board
800-0163
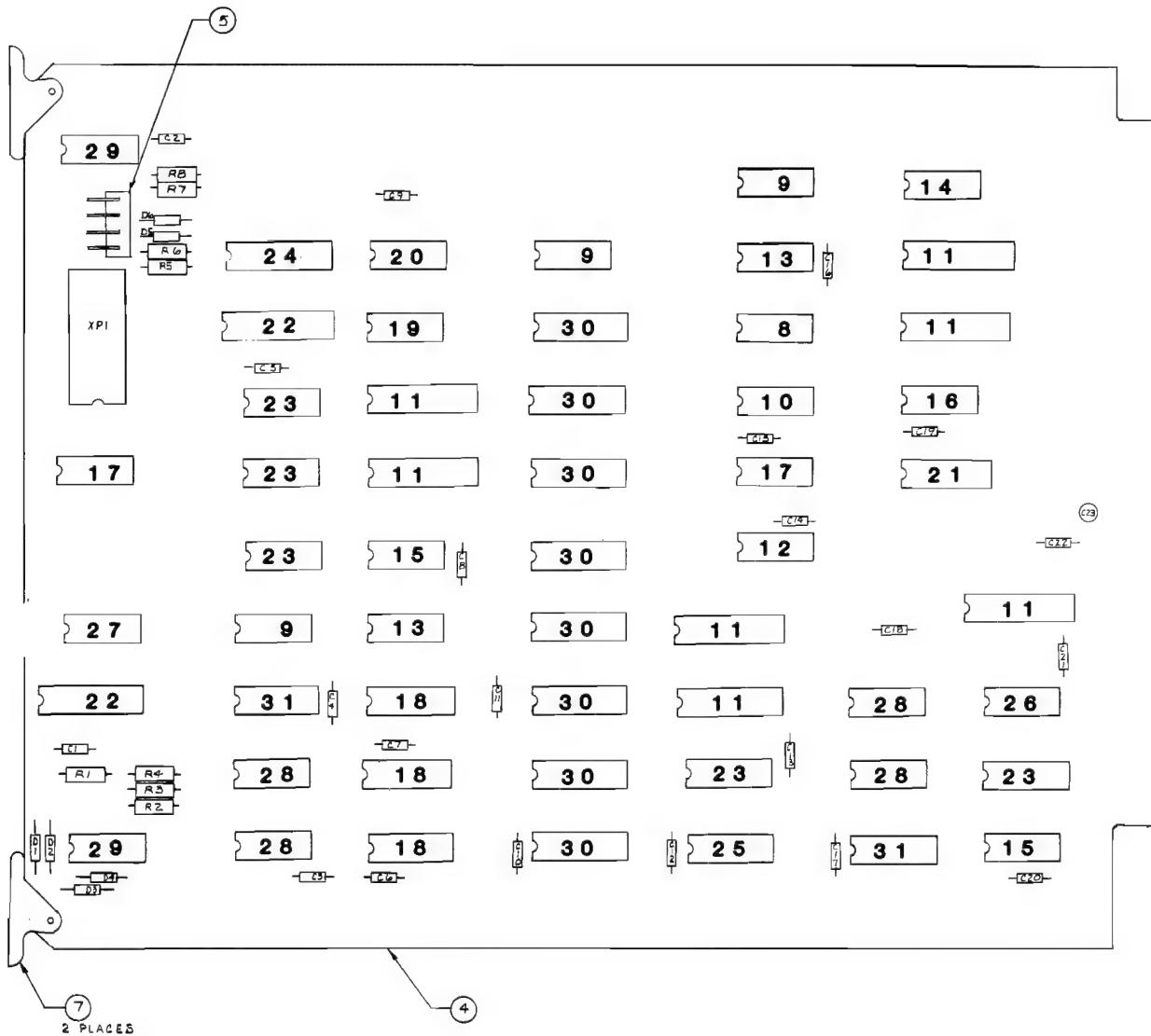
Schematics

G-80 X-Y BOARDS, BLOCK DIAGRAM

X-Y MONITOR

Model Number GO8-OO1

X-Y MONITOR

Model Number G08-OO3

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	RELEASED	SD 4-20-81	A. ARON

38

X-Y Control Board

Gremlin Industries, Inc.
San Diego, California 92123

SIZE	CODE IDENT NO.	DRAWING NO.	REV
D		800-0163	A

SCALE NONE   SHEET 6 OF 6

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	RELEASED	4·20·81	A. AHN

DRAWN SON DUONG 10-8-80
CHECKED JEFF PEASE 11-3-80

NOTES :

◇ = 86 PIN CONNECTOR.

◯ = 4 PIN MOLEX

⬡ = 24 PIN SOCKET

800-3155 / 700-0059
NEXT ASSY / USED ON
APPLICATION

DO NOT SCALE DRAWING

39

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	RELEASED SD	4-20-81	H. AKON

+5
C1
.01 Mf

CD Ø
1
2
3
4

T
D/UX
XCL

74LS191 U15
74LS191 U16
74LS191 U17
74LS191 U18
74LS191 U19
74LS191 U20

74LS157 U5
74LS157 U6
74LS157 U7
74LS157 U8
74LS157 U9
74LS157 U10

CD 7
5
6
7
8

2

AD561 U1
AD561 U4

R1 3.9K   R3 1K
+12
C3 .01 Mf
U2 741
C2 .01 Mf
R2 2K   -12

C29   1000 PF

3
D/UY
YCL

R5 3.9K   R6 1K
+12
C27 .01 Mf
U3 741
C6 .01 Mf
R4 2K   -12

C30   1000 PF

74LS86 U29
74LS86 U29   BOX
74LS02 U53   BOS   14

+5
C28 .01 Mf

74LS86 U29   BOY

4

23 22 Z a
25 c
43 1 A y
26 d

C8, C26 .01 Mf   +5
C4 10 Mf   +12
C5 10 Mf
-12

PARTS LIST
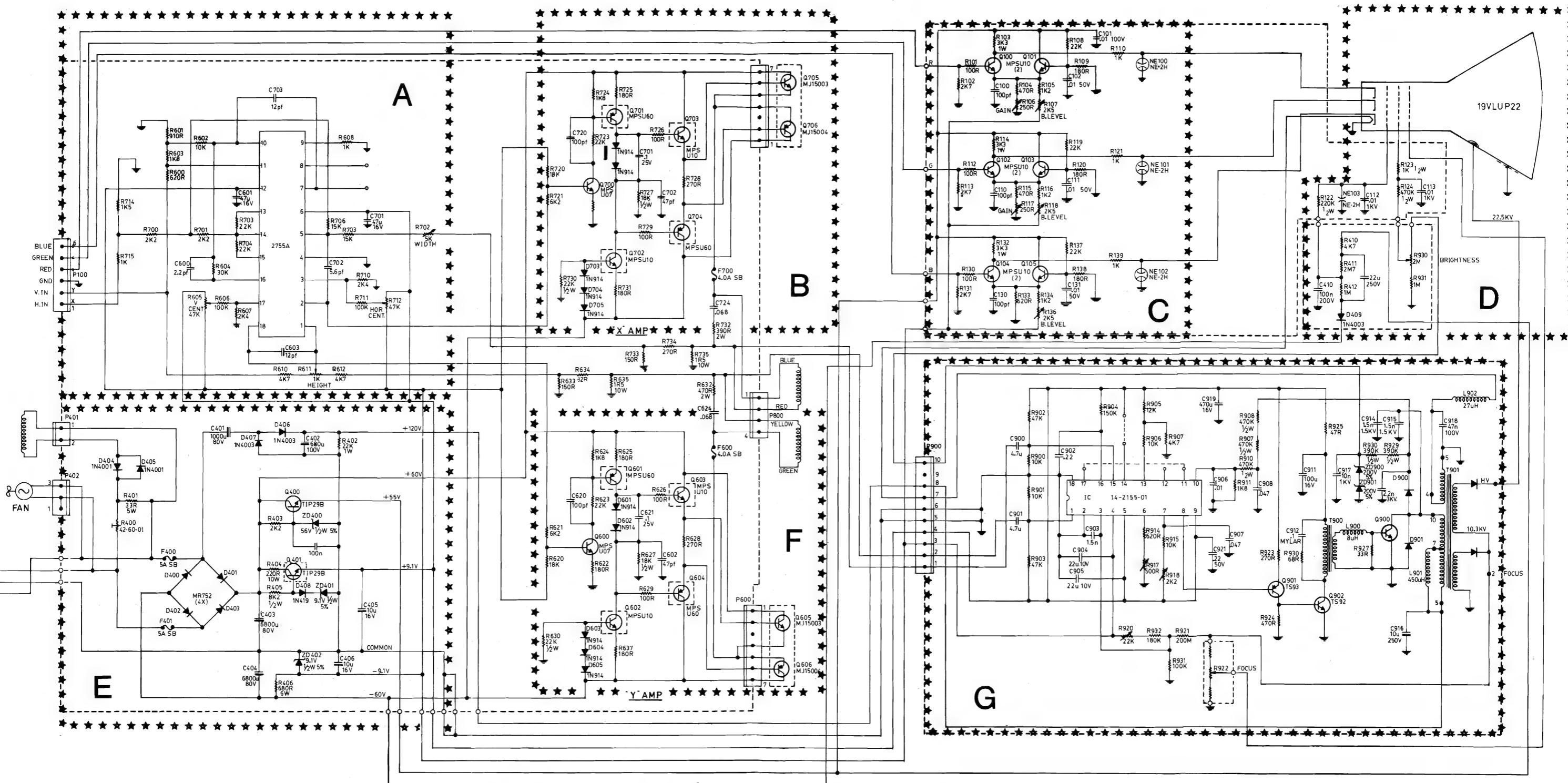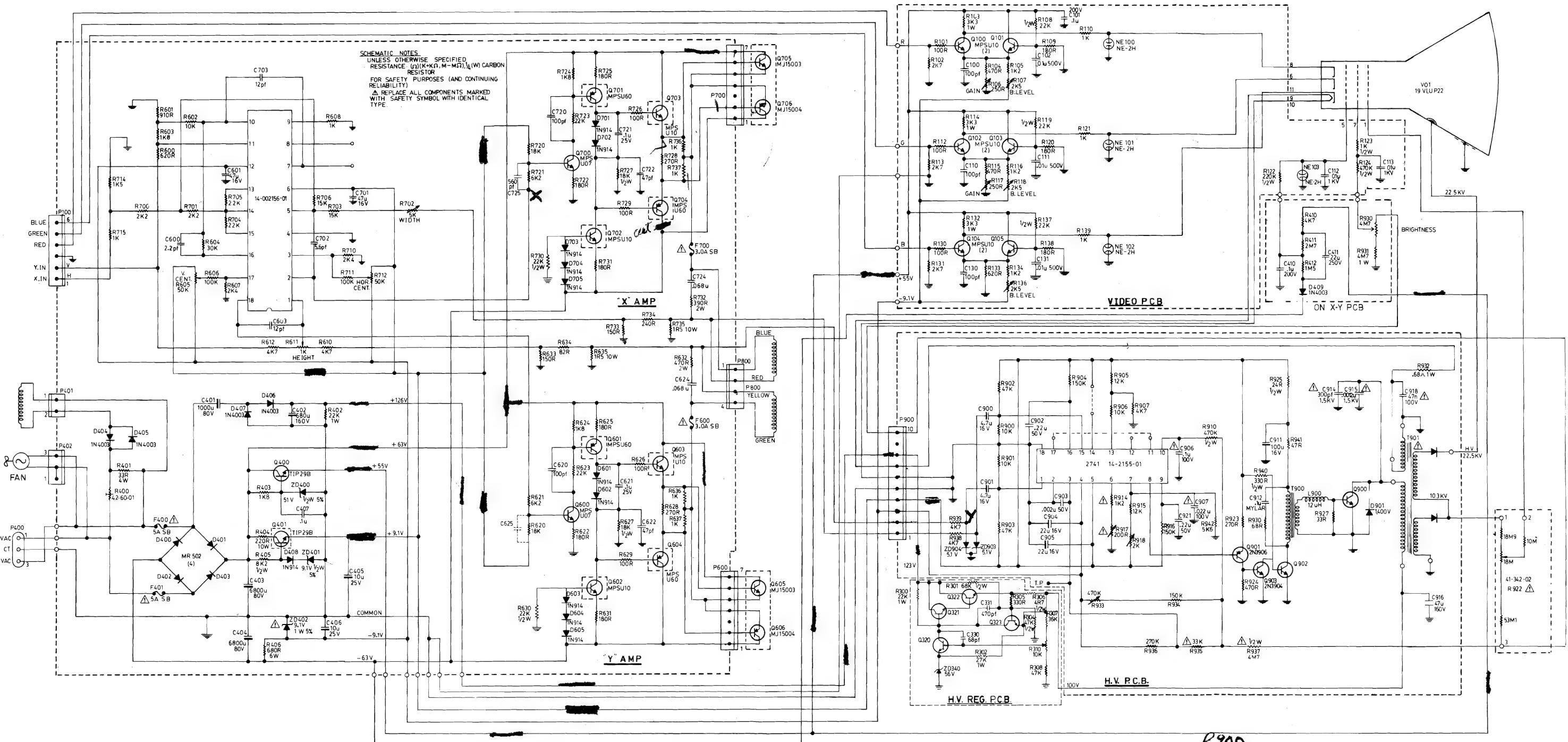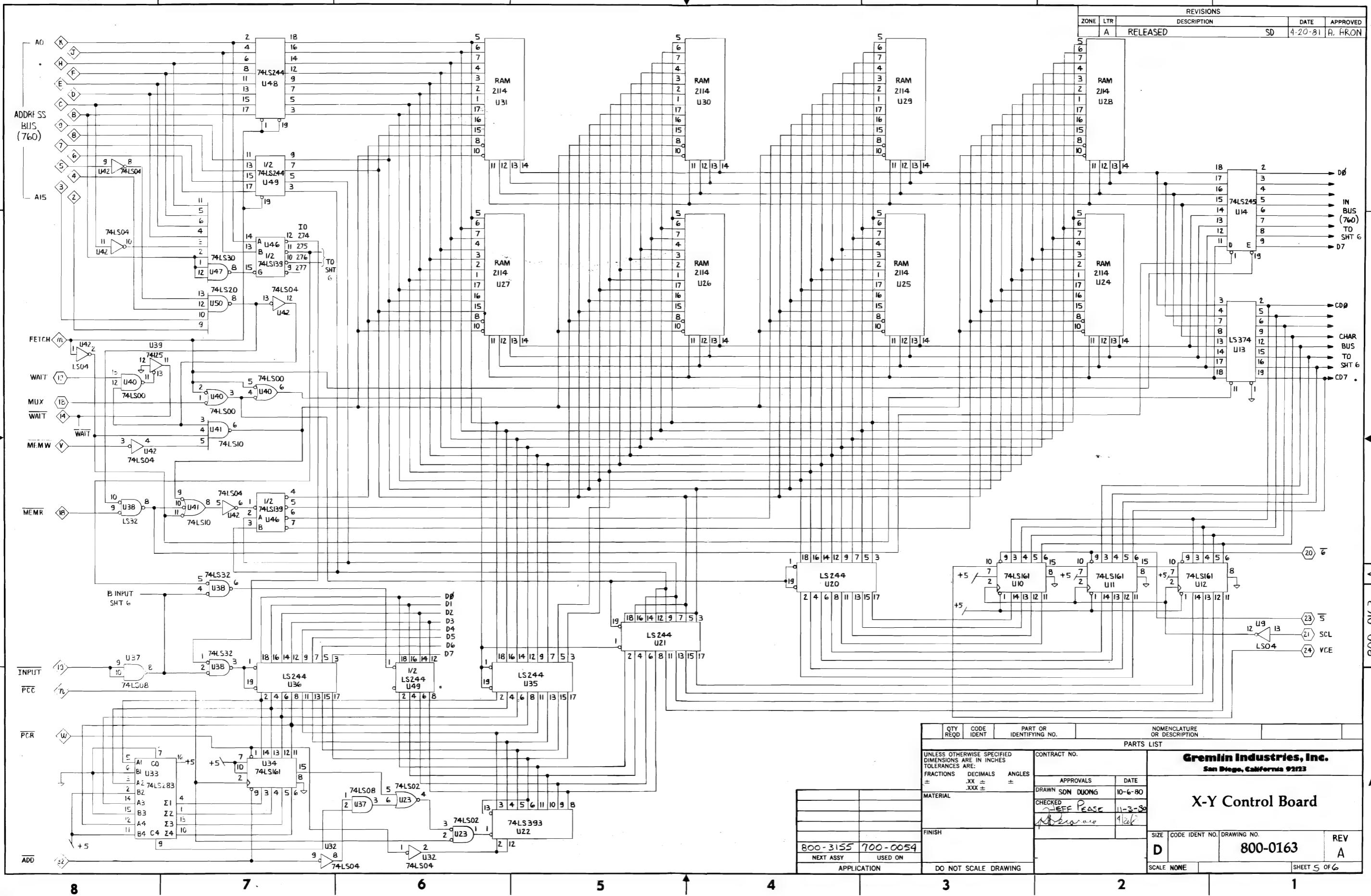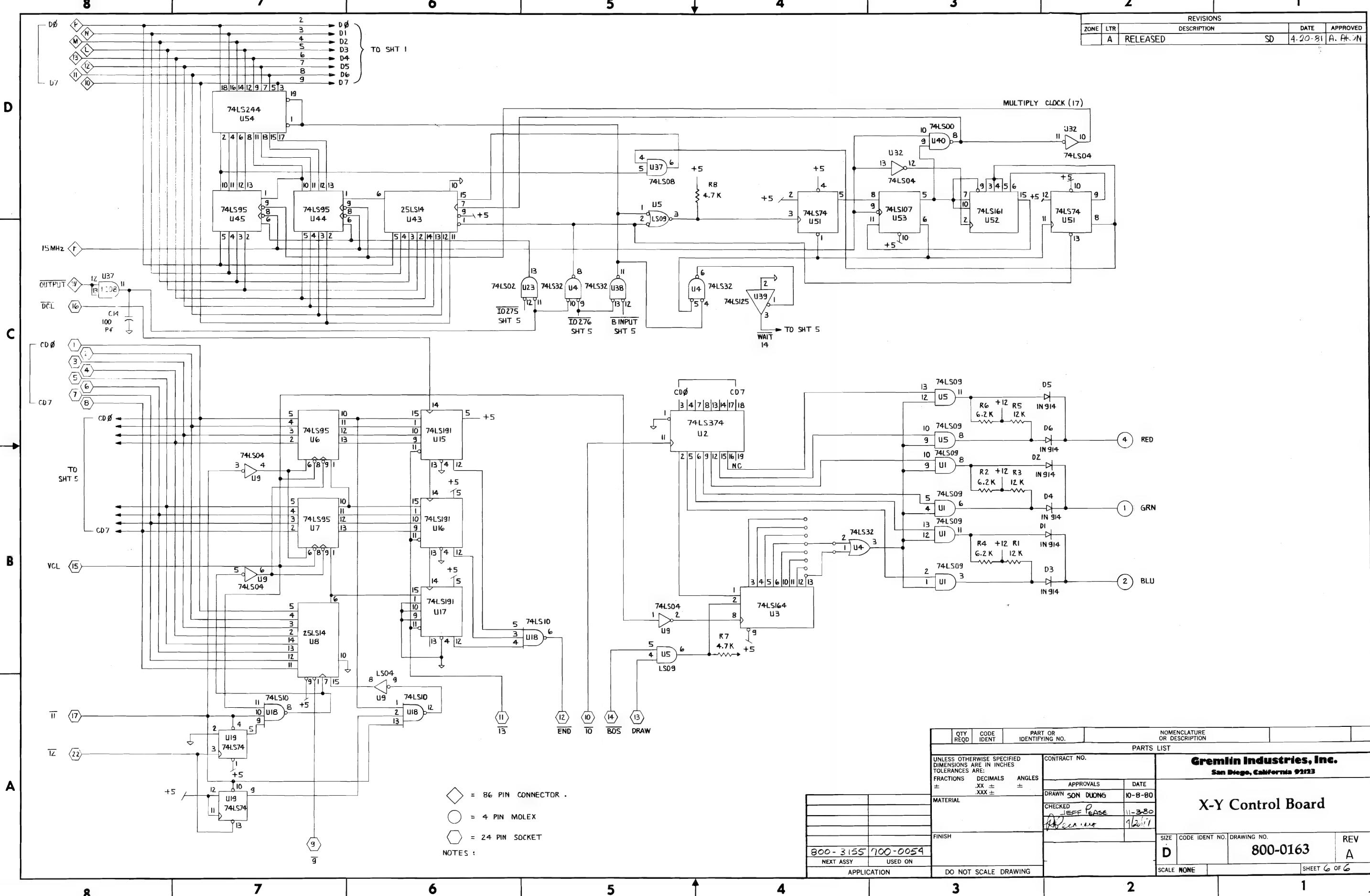
QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:
FRACTIONS ±   DECIMALS .XX ± .XXX ±   ANGLES ±

CONTRACT NO.

Gremlin Industries, Inc.
San Diego, California 92123

APPROVALS	DATE
DRAWN SON DUONG	3-12-81
CHECKED	4-20-81

MATERIAL

FINISH

X-Y Timing Board

| SIZE D | CODE IDENT NO. | DRAWING NO. 800-0161 | REV A |

800-3155 700-0054
NEXT ASSY USED ON
APPLICATION

DO NOT SCALE DRAWING

SCALE NONE   SHEET 5 OF 7

NOTES:

◇ = 86 PIN CONNECTOR.
○ = 4 PIN MOLEX.
⬡ = 24 PIN SOCKET.

800-0161 A

X-Y Timing Board

SIZE D   CODE IDENT NO.   DRAWING NO. 800-0161   REV A

SCALE NONE   SHEET 6 OF 7

800-3155   700-0054
NEXT ASSY   USED ON
APPLICATION

X-Y Timing Board

ZONE	LTR	DESCRIPTION		DATE	APPROVED
	A	RELEASED	SD	4-20-81	A. ARON

REVISIONS

SIZE D CODE IDENT NO. DRAWING NO. 800-0161 REV A

SCALE NONE SHEET 7 OF 7

800-3155 700-0059
NEXT ASSY USED ON
APPLICATION

DO NOT SCALE DRAWING

800-0161

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GLOSSARY

A0-A15   Address Bus 0-15. A0-A15 are the 16 lines of the CPU's address bus.

ADD   Add 10. ADD causes the Program Counter to jump ahead 10 addresses in video memory for the start of the next group of Symbol Instructions.

Analog Signal   A type of signal that represents all possible voltage levels between two predetermined levels.

Blank   Turn off the electron-beam.

BOS   Beam Off Screen. BOS, when low, blanks the beam whenever the beam moves off the four sides of the screen.

Cathode   A piece of metal in the neck of a CRT that, when charged with a voltage, emits electrons for the beam.

CD0-CD7   Character Data, Bits 0-7. CD0-CD7 represent the 8 data lines from video memory.

D0-D7   Data Bits 0-7. D0-D7 represent the 8 data lines of the microprocessor's data bus.

DCL   Draw Clock. DCL is generated from DRAW and VCL; it clocks the Vector Length counters down.

Deflection Amplifier   One of two power amplifiers in the X-Y monitor that generate deflection current for the deflecton coils.

Deflection Coil   One of two coils surrounding the neck of CRT that create a magnetic field to deflect the beam horizontally or vertically.

Deflection Current   The current through either deflection coil that is proportional to the amount of beam deflection.

Digital Signal   A type of signal that switches between 0 volts and typically +5 volts only.

Digital-to-Analog Converter (D/A)   A circuit or IC that converts a particular digital word into one voltage level.

DRAW   DRAW is generated by the Timing Board and is used to cause the beam to unblank.

D/UX, D/UY   Down/Up X, Y. D/UX, Y tells the Up/Down counters on the Timing Board to count either up or down.

Electron-Beam   A stream of electrons shaped into a thin ray that, when intensified, lights up the point it strikes on the inside surface of the CRT. There is one beam in a black-white monitor and three beams in a color monitor.

END   END goes low to signify that the line has been drawn.

FETCH   FETCH enables the various multiplexers on the Control Board, and latches data from video RAM.

Flyback Transformer   A transformer that produces high-voltage for the X-Y CRT. In raster-scan systems, this device also generates the "flyback" pulse to move the beam to the top of the screen.

Line Instructions   The upper portion of video memory that contains groups of 4 line words. Each group of four represents one line of the symbol to be drawn.

MEMR Memory Read. MEMR is generated from the CPU Board to take data out of video RAM.

MEMW Memory Write. MEMW is generated from the CPU Board to store data in video RAM.

Multiplexer A circuit or IC that accepts outputs from a number of devices but passes the outputs from only one device at a time.

MUX Multiplexer. MUX is combined with FETCH to control the enabling of multiplexers on the Control Board.

PCC Program Counter Clock. PCC is generated from SCL and it advances the Program Counter.

PCR Program Counter Reset. PCR resets the Program Counter to the address of the first Symbol Instruction in RAM. Its frequency is 40 HZ.

Program Counter On the G-80 Timing Board, the Program Counter is the circuit that addresses video memory to release the Symbol Instructions.

Raster The pattern of horizontal lines created by the electron-beam's movement on the inside surface of the picture tube (CRT).

Raster-Scan Monitor A black-white or color monitor in which the electron-beam always moves in a predetermined way, forming a pattern of raster lines on the screen.

SCL Sequence Clock. SCL is used to clock the Timing Generator, and it clocks the Vector Address Counter.

Symbol Instructions The lower portion of Video memory that contains groups of 10 symbol words. Each group of 10 represents one complete symbol to be drawn on the screen.

Timing Generator On the G-80 Timing Board, the Timing Generator produces a sequence of 15 signals that latch the words from video memory into various parts of the X-Y boards.

Unblank Turn on the electron-beam.

VCE Vector Count Enable. VCE enables the Vector Address Counter so that it may count.

VCL Vector Generator Clock. VCL is used on the Control Board in computing the length of a line to be drawn. Its frequency is 2.5 MHZ.

Vector Address Counter On the G-80 Control Board, the Vector Address Counter addresses video memory to release the Line Instructions.

Vector Length Counter On the G-80 Control Board, the Vector Length Counter is loaded with the length of the line to be drawn.

WAIT WAIT periodically stops the PCU so other circuits can gain access to video memory.

X-Axis The imaginary line that describes the horizontal movement of the beam on the screen.

XCL X Clock. XCL clocks the X-position Up/Down counters with pulses that represent the vertical line length and angle.

X-Y Monitor A black-white or color monitor in which the electron-beam can be moved in any direction, depending on how it is deflected.

X Up Down Counter The Up/Down Counters on the Timing Board that contain the digital value of the beam position on the X-axis.

Y-Axis The Imaginary line that describes the vertical movement of the beam.

YCL   Y Clock. YCL clocks the Y-position Up/Down counters with pulses that represent the horizontal line length and angle.

Y Up/Down Counter   The Up/Down Counters on the Timing Board that contain the digital value of the beam position on the Y-axis.

1-14   These signals are sequentially produced by the Timing Generator to latch the Symbol and Line Instructions from video memory into specific locations on the Timing and Control Boards.

Notes

Notes